APPENDIX 8

Response to Peer Review Comments on Draft Klamath River TMDLs

North Coast
Regional Water Quality Control Board
June 2009

1.1 Introduction

In accordance with Section 57004 of the California Heath and Safety Code, the North Coast Regional Water Quality Control Board (Regional Water Board) is required to receive external scientific peer review of the scientific basis of any proposed amendment to the *Water Quality Control Plan for the North Coast Region* (Basin Plan). For the Klamath River TMDL, the proposed Basin Plan amendment (BPA) will incorporate the Action Plan for the Klamath River Temperature Dissolved Oxygen, Nutrient, and MicrocystinTotal Maximum Daily Loads (TMDL), supported by the TMDL Staff Report. Therefore, the Peer Review Draft Staff Report for the Klamath River TMDLs was reviewed by four peer reviewers. The reviewer's comments and Regional Water Board staff responses are presented below.

1.2 Response to Peer Review Comments

Comments of: Christopher A. Myrick, Ph.D.
Colorado State University
Department of Fish, Wildlife, and Conservation Biology

Comment M1:

Nutrient allocations and chlorophyll-a, Microcystis aeruginosa, and microcystin numeric targets to Copco 1 and 2 and Iron Gate Reservoirs developed to control bluegreen algae blooms, associated toxins, and protect recreation and cultural beneficial uses.

The methods used to develop the proposed TMDL for nutrient allocations appear to be based on sound scientific practices and principles. Unlike some of the earlier work in the Klamath system that focused solely on the Klamath River mainstem, the information used to develop the TMDLs also incorporated contributions from tributary streams. It was also good to see the acknowledgement that the upper Klamath River region has a high natural nutrient load that historically caused significant blooms of phytoplankton and other forms of algae.

One concern with the nutrients/organic matter standards (Table 5.1) proposed for the Iron Gate Hatchery is that it may not be realistic to expect the hatchery to be able to achieve a zero net increase of nutrient and organic matter loads between the hatchery intake(s) in the reservoir and the hatchery discharge. By their very nature fish hatcheries will produce organic matter (excess feed, fish wastes, etc.) and while the use of settling ponds and careful control of feeding rates can reduce the amount of organic matter produced, they do not wholly eliminate it.

The use of the established World Health Organization standards for microcystin drew upon a body of existing public health research and by selecting the low heath effect level (<4 µg/L) shows due concern for minimizing the impacts on beneficial uses of the river. The correlations between the microcystin and the *M. aeruginosa* cell density research cited in the development of the *Microcystis* standard (e.g., Figure 2.5) seem appropriate.

Response M1:

The project team wanted to make use of the large amount of monitoring data and scientific literature that was available regarding the Klamath Basin when developing the nutrient allocations and associated targets because in a naturally eutrophic system the margin for error for increases above background is very small. Phytoplankton blooms in Upper Klamath Lake, both natural background and the more extreme existing conditions, have an impact on downstream water quality. However, the bulk of the organic algal biomass reaching the location on the Klamath River now occupied by Copco 1 and 2 and Iron Gate Reservoirs is not actively growing or reproducing. It is when the Klamath River waters are slowed by the reservoirs, creating lake-like conditions, that phytoplankton growth increases to the point of creating nuisance conditions during the summer growing season.

The Iron Gate Hatchery discharge requires an NPDES permit and the discharge requirements of that permit must be consistent with the TMDL. The facility location provides limited space for treatment options for process water. PacifiCorp and California Department of Fish and Game, the co-permitees, will be required to meet discharge limits specified by the revised NPDES permit issued by the Regional Water Board to Iron Gate Hatchery. NPDES permits and TMDLs can incorporate compliance schedules that can take into account special circumstances that may require additional time to get the appropriate treatment technologies into place. A compliance schedule adopted as part of the permit would consider the time needed for the permittees to make any infrastructure improvements to the hatchery and to implement management measures that meet TMDL allocations. As described in the Implementation Plan, the hatchery may be able to achieve any remaining required load reductions through offset mitigation that would be coordinated through the Klamath tracking and accounting program being developed as part of the Klamath implementation plan. The final point is that the technical TMDL must assign allocations to all sources to the levels needed to meet water quality standards, without consideration of feasibility. During the implementation phase of the TMDL alternative strategies for achieving load reductions can be evaluated.

The initial Klamath TMDL targets for chlorophyll-a, *Microcystis*, and microcystin were derived from "*Technical Approach To Develop Nutrient Numeric Endpoints for California*" (Tetra Tech 2006) and other technical literature. Using monitoring data collected in Iron Gate and Copco Reservoirs, the project team was able to make a site-specific confirmation of the initial target values.

Comment M2:

Temperature and dissolved oxygen allocations to Copco and Iron Gate Reservoirs developed to support salmonid beneficial uses.

Iron Gate and Copco 1 and 2 reservoirs currently experience summer conditions that are stressful, at best, for the resident salmonids. Based on the information in the supporting documents and the draft TMDL, there are times when salmonids will experience lethal combinations of high temperatures and low dissolved oxygen levels. The approach taken in the proposed TMDL of a compliance lens (see Figure 5.9) is an interesting one, and in theory would provide the fish with narrow band of water with tolerable temperatures (< 19°C) and dissolved oxygen levels (> 85% saturation). Research on resident and anadromous salmonids in California suggests that they can maintain their body condition when exposed to temperatures in this range, and provided that the “compliance lens” affords them sufficient access to food resources, it should provide a useful refuge against a temperature-oxygen “squeeze”. One question about this approach is whether such a lens will form given the thermal and hydraulic conditions in the reservoir, and, if it does form, whether it will persist in the face of stochastic events such as strong winds.

An additional comment on the temperature and dissolved oxygen allocations is that their intention is to support the COLD fish (i.e., salmonids), yet there are other native species (see reports by Moyle [2002] and the National Research Council [2004] {#3913} for a comprehensive list of the species present) in the system that deserve protection, especially in light of studies (e.g. Castleberry and Cech 1993 that demonstrate that the other native fishes are affected by elevated temperatures and low dissolved oxygen levels. These fish might benefit from the standards, but it would be useful to conduct a more comprehensive evaluation of how the standards would affect them.

Response M2:

The TMDL Monitoring Plan (Chapter 7) recommends sampling to determine the integrity of the compliance lens. The minimum required thickness of the compliance lens is equal to depth of the river under a pre-disturbance regime. PacifiCorp’s 2009 Reservoir Management Plan evaluates the potential for aerating the entire water column for both fishery support and to inhibit nutrient export from bottom sediments.

The Regional Water Board has evaluated the life-cycle requirements of other aquatic life present in the reservoirs and has determined that the existing proposed compliance lens allocation specifications for temperature and dissolved oxygen are adequate to protect the most sensitive resident species, as well as anadromous species should fish passage for the dams be provided.

Comment M3:

Analysis of tributary effects of tributary stream flow rates on stream temperatures in the tributaries and mainstem of the Klamath River.

With the realization that conditions in the Klamath mainstem immediately below Iron Gate Reservoir can reach marginal levels (particularly in terms of temperature) during the hottest summer months, the inclusion of the tributary contributions as a function of their stream flow rates is very useful. The tributaries have historically been an important component of the system, both a spawning and rearing habitat for some of the anadromous salmonids, the provision of thermal refugia, and as sources of cooler, cleaner water, and ignoring those, as some previous studies have done, would have been fundamentally unsound (National Research Council 2007). As was the case with the nutrient standards, it was gratifying to see a modeling effort on the Klamath system that included the contributions of the tributaries to the thermal status of the system. The reviewer does not have enough of a background in hydraulic modeling to comment upon the technical nature of the modeling approach.

Response M3:

Thank you for your comment.

Comment M4:

Assessing the linkage between water quality and fish disease.
Fish diseases, in particular *Ceratomyxa shasta* and Columnaris have been repeatedly cited as major fish health concerns in the Klamath basin, particularly given the high summer water temperatures and generally stressful conditions that can predispose fish for infection. The report summarizes the most recent information available on the relationship between disease and temperature, and also mentions the potential effects of the increased organic matter and nutrient load on the secondary host (polychaete worms). The proposed temperature standards for the Iron Gate Reservoir tailrace and the Iron Gate Hatchery (18.8°C) should provide some protection against severe disease outbreaks, although the temperature does fall within the range categorized as having a high disease risk for juvenile rearing and adult migration. Nevertheless, given the natural conditions in the Klamath system above Iron Gate, it is unlikely that a much lower temperature could be achieved.

Response M4:

The relationship between the prevalence of fish disease and water quality conditions continues to be a very active area of research on the Klamath River with the results being reported at the annual Klamath River Fish Health Conference in Fortuna, California. Temperature is definitely an important component of the fish disease cycle but other water quality conditions contribute as well.

The temperature targets for the Iron Gate tail race and hatchery are not standards, but are interpretations of the conditions that meet the standard, which in this case are natural temperatures. Therefore, the Iron Gate tail race and hatchery targets were developed based on natural conditions, as opposed to conditions that fully support the beneficial use.

When implemented, the TMDL Monitoring Plan will provide information that enables continued development of a fish disease model that will contribute to an improved understanding of the effect of degraded water quality conditions on fish disease in the Klamath River.

Comment M5:

Overall, the proposed total maximum daily loads for temperature, dissolved oxygen, organic matter, and nutrients have been developed using information from a wide variety of scientific sources, and using established scientific principles. While the reviewer does have some minor concerns about the implementation of the standards, and in particular about whether the “compliance lens” will function in reality as well as it does as a conceptual model, there is nothing in the draft TMDL document to warrant a comprehensive revision. The reviewer does hope, however, that once the TMDLs are adopted and implemented, the North Coast Regional Water Quality Control Board will

continue to evaluate new data as it is collected and adjust the total maximum daily loads as necessary. The Klamath River system is a dynamic one, and the ongoing anthropogenic and climatic changes may lead to additional changes in the basin's hydrology and ecology that will require modification of the TMDLs in the future.
Response M5: The Regional Water Board will ensure that monitoring measures are included that will allow for evaluation of compliance lens effectiveness. The Regional Water Board is also dedicated to the concept of adaptive management, which requires continued data collection, data review and assessment, and updating TMDL implementation measures.

Comments of: Dr. Gregory W. Characklis
University of North Carolina at Chapel Hill
Department of Environmental Sciences and Engineering

Comment C1:

After reviewing these documents, my overall opinion is that the plan makes use of contemporary mechanistic water quality models that are based on sound scientific principles, and that the (largely) deterministic results appear to be reasonable given the data and information available. That said, my primary concern is that even state-of-the-art water quality models parameterized with extensive datasets are not terribly accurate, and are often unable to predict contaminant concentrations or loadings with what most would consider to be a reasonable level of accuracy. This shortcoming is certainly apparent throughout the peer-reviewed literature (e.g., Dorner et al. 2006; Reckhow 2003; Stow et al. 2003) and was a central theme in the National Research Council's 2001 report, "Assessing the TMDL Approach to Water Quality Management," which recommends explicit treatment and discussion of uncertainty as a part of the TMDL process. Consequently, reliance on deterministic modeling results without giving due attention to the (often substantial) levels of uncertainty attendant with these estimates can provide an incomplete picture to those seeking to interpret these analyses for decision making purposes. While I understand that there will never be enough data to fully characterize a complex natural system such as the Klamath, and that decisions of this kind must often be made without the benefit of complete information, characterizations of the nature and importance of gaps in data and understanding should be more explicit. Therefore, my primary suggestion would be that a more concerted effort be directed toward the evaluation and communication of the uncertainty inherent in these models. General comments related to this issue are provided below. Also included are sections that address the specific questions posed in the request for review.

Within the review documents, many of the determinations regarding the degree of allowable contaminant loading and the sources of that loading are made on the basis of comparisons between model estimates of "natural" background levels (made mostly without data) and model estimates of current conditions (some of which are made with the benefit of a calibration step involving current data). As such, it seems appropriate that a greater level of effort be taken to more clearly describe the degree of uncertainty attendant with both of these estimates. This will provide a better understanding of the probability that a given set of mitigating actions will have the intended result.

Concerns over the lack of attention to the uncertainty issue are heightened by several additional issues, mostly related to the issues of model calibration and subsequent "corroboration" (a term which I interpret as being intended to substitute for the more commonly used term "validation"). First, while effort was expended in calibrating the model for all 9 river segments using one year's (2000) worth of data, attempts to "corroborate", and thereby evaluate model performance independently, seem to have only been undertaken in a couple of upstream segments (i.e. those residing almost exclusively in Oregon)1. None of the California segments appeared to undergo any type of validation/corroboration analysis (with the exception of the estuary, segment 9). Predictions based on water quality models, even the most advanced models parameterized with extensive data sets, are often highly divergent from observations, and without any evaluation of model performance, it difficult to place a high level of confidence in these modeled results. This would seem to be relevant given that one of the central themes in the analysis involves comparing model results from "current" conditions with the results of models designed to estimate "natural" background conditions. Furthermore, it appears that in some cases relatively small deviations between modeled estimates of current and natural conditions serve as the basis for a decision on the location and magnitude of a loading reduction. While the choice as to whether or not these models are accurate enough to reasonably support decisions on actions is a matter for policymakers to decide, I think that some quantification and presentation of the uncertainty associated with these estimates would greatly facilitate more informed decisions.

I am aware and sympathetic to the argument that academics think there is "never enough data", but still believe that there may be opportunities to better convey the level of uncertainty in modeled estimates. Along those lines, it appears that the corroboration/validation efforts were limited by both data availability and the cost associated with doing additional modeling (explanation given Chapter 3, pg. 7). I do not know the relative roles that each played in the decision to forego the validation step, and of course if there are no data available to undertake additional modeling, that is one issue (although one that might be revisited). However, if data availability is not limiting, I would offer some suggestions.

If sufficient data on current conditions exists to reasonably validate the model for the lower (i.e. California) segments of the Klamath basin , a more rigorous quantitative approach to evaluating the confidence intervals associated with estimates of current conditions would allow for a more informed comparison of current and natural conditions. In addition, while historical data on "natural" conditions are not likely to be available, some attempt at a sensitivity analysis, including an identification of the most sensitive model inputs and an evaluation of the impacts that varying these inputs has on model estimates of water quality, would provide some sense of model limitations (as currently presented, at least in Figures 2.15 and 2.16, it appears that there is very little uncertainty in modeled natural conditions). In the event that data on current conditions in the lower segments (6-9) is lacking, such a sensitivity analysis could be undertaken here as well. Some justification for the ranges of input values selected would also be informative.

I might also suggest that if increased efforts are made to collect water quality data in the system, either as a part of this or subsequent efforts, some careful planning involving consideration of a joint modeling and monitoring approach might be useful. Current advancements in the science of merging observations and modeling results in water quality can significantly reduce the costs of rigorously characterizing conditions in a river system (LoBuglio et al. 2007; Money et al. 2009) and might be worth investigating at some point.
The existing data seems to suggest that human activities are contributing to water quality

impairment in the Klamath Basin. Nonetheless, the degree to which this impairment is occurring and the level to which current conditions deviate from natural conditions is very difficult to determine using modeling as a primary analytical tool. I understand that this may be all that is currently available, but believe that a more explicit treatment of the uncertainty associated with modeling results will provide decision makers with a more informed basis for making policy choices.

Let me reiterate that I find the models to be consistent with sound scientific principles, and the most up-to-date thinking on water quality models, the simple fact is that even state-of the-art water quality models are not terribly accurate. And, while one could always take issue with individual assumptions or particular input values, I am not sure that one set of choices would necessarily be better than others. I do believe, however, that the lack of explicit attention to the uncertainty issue could leave the impression that these models are more accurate than they actually are. Consequently, a more concerted effort to evaluate and communicate the uncertainty inherent in these models would seem appropriate.

Response C1:

Regional Water Board staff appreciate the reviewer's comments regarding uncertainty in the TMDL models, and recognize the value of uncertainty analysis. The Klamath TMDL development team (Regional Water Board, ODEQ, US EPA Regions 9 and 10, and TetraTech) considered how best to assess and quantify model uncertainty. Due to the size and complexity of the Klamath River, limited resources, and schedules, it was determined that quantitative uncertainty analyses and formal, quantitative sensitivity analysis were not feasible. However, the TMDL development team strove to minimize uncertainty in other ways.

Development and application of the Klamath River TMDL model has focused on key best practices identified in EPA's March 2009 "Guidance on the Development, Evaluation, and Application of Environmental Models," including peer review of models; QA project planning, including data quality assessment; and model corroboration (qualitative and/or quantitative evaluation of a model's accuracy and predictive capabilities). The Regional Water Board, ODEQ, US EPA Regions 9 and 10, and TetraTech have collaborated very closely over a five year period during the Klamath River TMDL modeling process at both technical and policy levels. In addition to the key practices noted above, model sensitivity and uncertainty analysis have been considered though to a lesser extent. Appendix 5 of the Klamath TMDL Staff Report, "Model Configuration and Results - Klamath River Model for TMDL Development" (Tetra Tech 2008a) details model assumptions, limitations, and uncertainty.

A formal, quantitative sensitivity analysis was infeasible due to the computational complexity of the Klamath River TMDL model. However, the sensitivity of important water quality conditions to various parameters and external forcing functions was indirectly analyzed through the iterative model calibration process. Model calibration and corroboration (aka "validation") involved repeated adjustment of model parameters and boundary conditions (which were based on available data) in order to achieve the best match between predictions and observations. This process inherently considered the sensitivity of model processes to influencing factors. Through this process and the more than forty subsequent allocation runs, it was clear that the model results are primarily driven by the magnitude and timing of boundary condition contributions (i.e., incoming loads from upstream and lateral boundaries). Model parameter sensitivity is much less influential. Therefore, the major focus of Klamath River TMDL model refinements was on acquiring and incorporating the most accurate and comprehensive data describing boundary conditions to reduce uncertainty.

Model corroboration was conducted for the Oregon segments of the Klamath River (Model Segments 1 through 5) for 2002. 2002 was selected for model corroboration because considerably more data were available for the upper portion of the river in 2002 than for other years. While cost was a factor, the model was not run downstream (Segments 6 through 9) for 2002 primarily due to limited boundary data for the downstream segments. In general, boundary condition data are limited in terms of representing the full range of temporal, spatial, and parameter variability. Thus, it is very likely that evaluation of additional calibration/corroboration would be more tied to data limitations/ uncertainty than model performance.

Model assumptions, limitations, and sources of uncertainty were identified in the TMDL and modeling reports, however a quantitative uncertainty analysis was deemed inappropriate. Uncertainty analyses such as interval number, fuzzy parameter, Monte Carlo, and Bayesian are not applicable to the Klamath River TMDL model due to the model's computational complexity and the development/application timeframe. Running the Klamath River TMDL model requires more than 4 days of continuous simulation using a 2.66 Ghz duo-core computer and results in generation of over 5 GB of results. It's simply not practical to run hundreds, thousands, or tens of thousands of scenarios to support an uncertainty analysis. In addition to computational limitations, a quantitative uncertainty analysis usually requires knowledge of the statistical distribution of data and parameters. This is not possible for the Klamath River TMDL model due to spatial and temporal data limitations. Data are generally only available during a snapshot in time at a particular location. Quantitative uncertainty analysis would provide a very limited assessment of the situation. Data limitations are largely the reason that a quantitative error analysis was also not performed on the water quality simulation. Rather, time series plots of model results versus observed data were evaluated. They provide more insight into the nature of the system and are more useful than a statistical comparison. Trends in the observed data and cause-effect relationships between various parameters can be replicated with a model, although precise values at each and every point in time may not be. In addition to computational and data limitations, uncertainty associated with the underlying model theory and its mathematical representation cannot be quantified either.

In addition to the application of the TMDL model, other lines of evidence were applied to assist in confirming allocations and targets, such as the California Nutrient Numeric Endpoints analysis (see Appendices 2 and 3), tributary temperature modeling (see Section 3.3.3.2), and statistical analysis of empirical data (see for example Section 2.3.2.2) . In addition, the Regional Water Board, ODEQ, and EPA Regions 9 and 10 have developed a Memorandum of Agreement (MOA) that establishes a framework for joint implementation of the Klamath River TMDLs. Among other things, the MOA includes agreements to:

- Work to develop and implement a joint adaptive management program, including joint time frames for reviewing progress and considering adjustments to TMDLs;
- Work with the Klamath Basin Water Quality Monitoring Coordination Group and other appropriate entities to develop and implement basinwide monitoring programs designed to track progress, fill in data gaps, and provide a feedback loop for management actions on both sides of the common state border; and
- Work to develop and implement a basinwide water quality accounting and tracking program that would establish a framework to track water quality improvements, facilitate planning and coordinated TMDL implementation, and enable appropriate water quality offsets or trades.

Regional Water Board staff's intent is for these implementation actions to minimize uncertainties and to inform decisions related to any adjustments / modifications to the TMDL that may need to be made.

Based on all of these considerations, Regional Water Board staff believe that the Klamath River TMDL models are performing well and are suitable tools for establishing Klamath River TMDL allocations and targets.

Comment C2:

1) **Nutrient Allocations and chlorophyll-a, *Microsystis aeruginosa*, and microsystin numeric targets for Copco 1 and 2 and Iron Gate Reservoirs developed to control bluegreen algae blooms, associated toxins, and protect recreation and cultural beneficial uses.**

The use of chlorophyll-a as an indicator of algal growth, including Microsystis *aeruginosa*, and the accompanying microsystin seems supportable given the data presented in Figures 2.1-2.6. Similarly, the choices of target values for these three parameters seem reasonable. I am less sure of the nutrient allocations and whether the targets suggested can be fully supported by the evidence presented. There is very little effort directed toward characterizing the degree to which nutrient inputs contribute to increased algal growth. Model runs to determine algal and chlorophyll-a concentrations were undertaken for river segments upstream of the reservoirs, in particular segment 5, but in this case the models tended to substantially overpredict both, by several multiples in most cases (Figures H-17, H-24, H-31 and H-39). While the instream models are different from that (CE-QUAL) used to model the reservoirs, it does not provide a high degree of confidence that the nutrient input targets are an accurate indicator of the outcome in terms of reducing chlorophyll-a, *Microsystis aeruginosa*, and microsystin to desired levels.

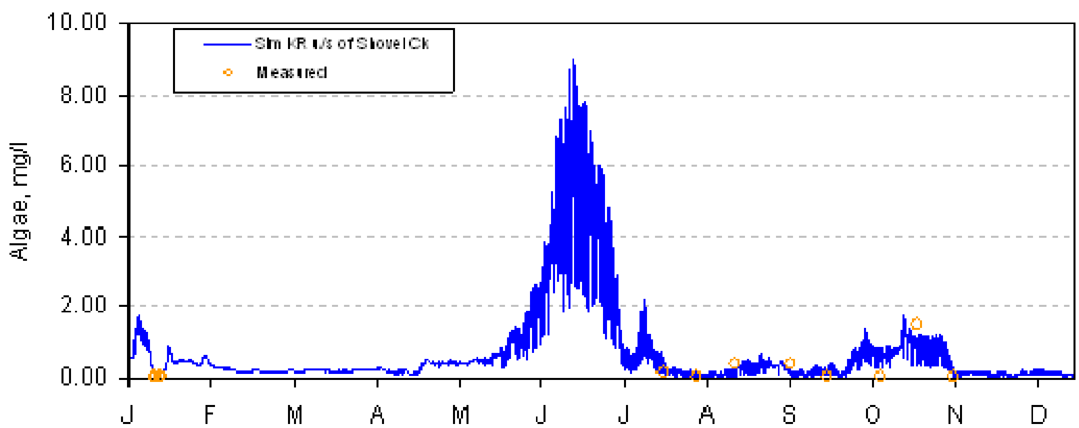
Further downstream in Copco and Iron Gate reservoirs, observations of chlorophyll-a concentrations are used to calibrate the CE-QUAL model across a range of depths on several dates (Figures I-6 and J-6). Unfortunately, there is no validation exercise, and the scale on the horizontal axis of the calibration figures is in mg/l (the standard for chlorophyll-a is measured in ug/l) making it difficult to determine the relative degree of accuracy inherent in the calibration exercises. As a result, the linkage between nutrient

inputs and the biological endpoints of primary interest (i.e. chlorophyll-a, *Microsystis aeruginosa*, and microsystin) is unclear, and I would have liked to have seen a more explicit rendering of the uncertainties associated with these predictions.

Response C2:

Nutrient contributions to increased algal growth are represented in the Klamath River TMDL model using modern water quality modeling technology. Both phytoplankton and periphyton are represented in the system. The prevalence of one category of algae versus the other depends on the characteristics of the segment. Nutrient impacts on phytoplankton are significant only in the reservoirs, where water retention time is long enough to enable algae to grow. In the fast-flowing riverine segments, such as segment 5, phytoplankton growth is insignificant. Thus, the algae biomass in the riverine reaches is not related to the nutrient concentration. The simulated phytoplankton biomass is similar to the observed data in segment 5 and other segments.

In a number of situations it appears that the model over-predicts chlorophyll-a levels. Predictions for the Klamath River at Shovel Creek (as shown below) exhibit high concentrations in the middle of the year. This occurs largely due to upstream conditions being carried downstream, and do not reflect in-river growth. In many of these situations, chlorophyll-a data are not available for comparison.



Although the Copco and Iron Gate model segments were not corroborated for an independent time period, calibration results for the reservoirs demonstrate that the model predicts trends in the observed data with respect to algae growth. It's acknowledged that the scales in Figures I-6 and J-6 don't provide tremendous resolution, however, even at the resolution presented the model clearly predicts increased chlorophyll-a levels during the summer and early fall. Corresponding data in the plots (at the surface) also show this trend.

As described in Section 3.3.4, in order to develop a final nutrient reduction allocation for PacifiCorp to control the blue-green algae in Copco and Iron Gate Reservoirs, iterative scenario runs (T4BSRN-C) were conducted using the Klamath River TMDL model for segments 6 and 7, to obtain desired nutrient concentrations under which the numeric target of 10 ug/L of chlorophyll-a at the surface of the two reservoirs is met.

Supporting lines of evidence were also used to develop the nutrient concentration targets for Copco and Iron Gate Reservoirs. The California Nutrient Numeric Endpoints framework and associated steady-state BATHTUB nutrient response model was applied to 2002 and 2005 using intensive monitoring data in Copco and Iron Gate Reservoirs (Tetra Tech, 2008, *Nutrient Numeric Endpoint Analysis for the Klamath River, CA* [Appendix 2 of Staff Report]). The BATHTUB analysis provides a reasonable fit to growing season mean chlorophyll a concentrations observed in the two reservoirs. BATHTUB was also used to determine the nutrient reductions needed to achieve the target of a summer average concentration of 10 µg/L chlorophyll *a*. The BATHTUB analysis suggested that a total reduction in phosphorus load of around 90 percent and a total reduction in total nitrogen load of around 65-70 percent would be needed to achieve the algal concentration target for year 2000, consistent with the reduction needs predicted by the TMDL model. The NNE analysis also looked at cyanobacterial dominance in Iron Gate and Copco Reservoirs using the Blue Green Index. This indicated that current phosphorus concentrations should lead to 50 - 60 percent or more of the algal biomass as cyanobacteria, consistent with observations of cyanobacterial blooms. Under the proposed nutrient targets, the fraction of biomass as cyanobacteria is predicted to decline to 20-25 percent of algal biomass.

Comment C3:

With regard to the allocation of “zero nutrient loading from the reservoir bottom sediments”, I have a few questions. Is this intended to mean zero additional, *human induced*, nutrient loading from the bottom sediments, or zero nutrient loading of any kind? If the latter, this seems a bit strange, as I would guess that even in the river’s natural state, or a condition in which the reservoir exists without human-induced nutrient loadings, that there are sure to be some natural nutrient additions to the system. Some of these are bound to be in a particulate form and make their way to the sediments where they would contribute some (non-zero) nutrient load on the water column. In either event, the concept of a “zero” allocation target is a difficult one to conceive of in any natural context, and even if it were possible, the evidence presented does not provide a high level of confidence that the biological endpoints will be reached.

Response C3:

The rationale for the “zero nutrient loading from the reservoir bottom sediments” is related to the change in form and timing of nutrient release into to the water column as a result of contact between the anaerobic hypolimnion water column and reservoir sediments. The reservoir, as an anthropogenic structure, has created conditions during summer stratification that result in the release of dissolved inorganic nutrients into the water column which are then transported downstream contributing to biostimulatory conditions below Iron Gate Reservoir, Under conditions present with a free flowing river, a similar release would not occur. The allocation amount was not set solely to address targets within the reservoir. Rather the allocation reflects the estimated contribution of TP and TN released to the water column during the summer stratification period. Section 4.2.2.2 has been revised to better describe the quantification of nutrients released from the reservoir bottom sediments.

Comment C4:

(2) Temperature and dissolved oxygen allocations to Copco and Iron Gate Reservoirs developed to support salmonid beneficial uses.
Dissolved oxygen levels and temperature are clearly linked, and the data and analyses on fish behavior makes a good case that raising D.O. and lowering temperature in the system will enhance fish survival and reproduction. The temperature model seems to calibrate reasonably well for the Copco and Iron Gate reservoirs (Figures I-1 and J-1), but some validation step would have been comforting. That said, I am not sure I understand how the targets for temperature will be met, as the thought that the difference in reservoir inflow and outflow in Copco and Iron Gate can be limited to (on average) 0.1 C and 0.3 C, respectively, seems very unlikely given the temperature data presented in Figures 4.7 and 4.8. The residence time in the reservoirs, and hence the longer exposure to sunlight and, particularly in summer, higher air temperatures would seem to make achieving this goal difficult, even with the understanding that dam releases often involve cooler water from the middle of the water column.

Response C4:

One of the primary tasks associated with the development of TMDLs is the interpretation of water quality conditions, both current and compliant, as they relate to water quality standards. Given that the water quality temperature objectives for temperature require natural temperatures, Regional Water Board staff endeavored to define the natural temperature increase that would be expected in a natural, free-flowing state, and thus define a temperature increase that is compliant with the water quality objectives for temperature. The 0.1 ^{o}C and 0.3 ^{o}C difference in reservoir inflow and outflow in Copco and Iron Gate reservoirs, respectively, represent the temperature increases expected in a free-flowing, natural state.

Comment C5:

The concept of the “compliance lens”, while being new to me, is an interesting one and in theory could be quite useful, however, I am skeptical regarding the ability to design a thermal load allocation strategy that will reliably result in such a lens. While it is tempting to view reservoirs as entirely quiescent bodies of water, almost all have circulation patterns driven by wind, inflows, etc. The thought that such a large and complex natural system could be fine tuned to the degree necessary to consistently create a lens with the desired D.O. and temperature conditions strikes me as being very optimistic. Nonetheless, given the information presented in the report, if such a lens could be established, it would appear to offer a “home” to sensitive fish populations, provided they are capable of finding and making use of such regions, and assuming that no other factors (e.g., food availability) impact their ability to remain in them (I know very little about fish behavior/biology, so I am not qualified to offer many useful comments on these issues).

Response C5:

The compliance lens allocation was designed to meet the minimum conditions for beneficial use support. The allocation is required due to conditions caused by the presence of the dams, however specification of how the allocation is met is ultimately the responsibility of PacifiCorp.

Comment C6:

Lastly, I am curious as to why climate change is not explored as a possible reason for increased reservoir and stream temperatures. Surely there is data available on air temperatures in the basin, and it would be relatively easy to look for trends in increasing mean, high and low values over time. If air temperatures have been increasing, particularly increased low temperatures at night (which seem to be where the biggest impacts are observed), this would appear to be an obvious contributor to increased water temperatures in the Klamath. These are certainly "human-induced" increases to thermal load, but local actions to combat these contributions would not likely be effective. As a result, some discussion of this issue, and an analysis of the size of climate change related contributions, if any, to those from other sources (return flows, altered channel dimensions, etc.) would seem to be important when developing mitigation strategies.

Response C6:

Regional Water Board staff have added a discussion of the increase in air and water temperatures in Section 1.6.4, Climate. The added text discusses Bartholow's (2005) findings that average Klamath Basin air temperatures have increased by 0.5 ^{o}C per decade.

Comment C7:

(3) Analysis of the effects of tributary stream flow rates on stream temperatures in the tributaries and Mainstem of the Klamath River.

I hope I have not missed something in this area (and I believe I have exercised due diligence), however if I have not, it appears to me that there is insufficient data and/or evidence to support even general assessments of changes in the thermal conditions of the Klamath tributaries, or to evaluate actions that might mitigate any potential impairment. I understand that professional judgment will play a role in decisions on whether and how to regulate these systems, and that these decisions must often be made without the benefit of sufficient data to conclusively demonstrate that the proposed actions will work as intended. Nevertheless, in this case, the relative dearth of information makes it difficult for me to understand how there is a basis for any considered decisions.

Response C7:

Regional Water Board staff have added a discussion to section 3.3.3.2 of the considerable modeling efforts, and data they rely on, previously completed and that this analysis draws from. A synopsis of the data used as the basis of the previous modeling work, and calibration results are presented here, and included in the text:

"The Heat Source model was previously implemented in the Scott River as part of the Scott River TMDL development process. The original model development, described in detail in the *Staff Report for the Action Plan for the Scott River Sediment and Temperature Total Maximum Daily Loads* (Regional Water Board 2005), was based on:

- comprehensive mapping of the Scott River channel and nearby vegetation using high-resolution aerial imagery,
- substrate and width-to-depth data from habitat typing surveys,
- measured water temperatures at all 11 tributaries with surface connection to the Scott River,
- measured air temperatures at 6 sites distributed along the longitudinal axis of the Scott River,
- measured relative humidity data at 5 sites distributed along the longitudinal axis of the Scott River,
- measured wind speeds at 3 sites distributed along the longitudinal axis of the Scott River,
- periodic flow measurements at 10 sites distributed along the longitudinal axis of the Scott River and the continuous flow record at the “Scott River near Fort Jones” USGS gauge, and
- a thermal infrared survey covering the entire modeled reach (Watershed Sciences, 2004).

The model was calibrated for the August 27 - September 10, 2003, time period using temperature data from 21 sites distributed along the longitudinal axis of the Scott River, and validated using temperature data at 18 sites during the July 28 - August 1, 2003, time period (three sites were not deployed until after August 1, 2003, and were unavailable for validation).
The mean absolute error for the validation period at the 18 sites ranged from 0.5 to 2.4 ^{o}C (0.9 to 4.3 ^{o}F), and averaged 1.1 ^{o}C (2.0 ^{o}F). Average bias of the daily average error for the validation period at 18 sites ranged from –1.9 to 2.1 ^{o}C (3.4 to 3.8 ^{o}F), and averaged -0.2 ^{o}C (-0.36 $_{o}$F). The average bias of the Scott River daily average temperature near the mouth (river mile 0.5) was 0.2 ^{o}C (0.36 ^{o}F).

The Shasta River water quality model is an application of the Tennessee Valley Authority’s River Modeling System (version 4), and was originally developed by Abbott (2002). The model was later refined by Deas and Geisler (2004) to take advantage of better refined hydrography data and a relatively large quantity of flow and water temperature data. The model was calibrated and validated using data from 8 flow gauges and 11 water temperature data loggers distributed along the 65.3 km (40.6 mi) simulated length of Shasta River between Dwinnell Dam and the Klamath River (Deas and Geisler 2004)."

Shasta River model validation statistics were added and presented in Table 3.2.

Comment C8:

The question of whether or not a thermal impairment exists in these tributaries, and as a result, in the mainstem of the Klamath itself, revolves primarily around a comparison of natural and current conditions. It appears that both sets of conditions are evaluated almost entirely on the basis of modeling results. I could find no evidence that models of temperature in these tributaries had been calibrated with actual observations, much less validated. The only data related to this question appeared to be in Figures 2.11 and 2.13, which show some data on mainstem temperatures at the points where the tributaries enter the mainstem, but do not provide enough information to make any determination of their potential impact. The model results are contingent on accurate information related to flow rates, channel morphology, runoff inputs, effective shade and a host of other factors for which very little current data appears to exist (information on what would constitute "natural" conditions is, of course, even more scarce). Previous modeling efforts are alluded to and seem to serve as a basis for the modeling exercises in this effort (Chap. 3, pg. 11), so maybe there was some data associated with them. If so, it would be nice to include some discussion of this. Even if a comprehensive set of accurate model inputs were available, however, I think it would be difficult to use these models to try to distinguish the relatively subtle changes in stream temperature that would form the basis for a decision on whether or not the tributary were impaired (or whether the tributary contributed to the impairment of the mainstem of the river).

Response C8:

Please see the response to the previous comment. Also, the assumption that "relatively subtle changes in stream temperature" have occurred as a result of human activities in Klamath tributaries is overly broad. The temperature analyses conducted in support of the Scott and Shasta TMDLs demonstrate that the major changes in hydrology and vegetation that have occurred in those basins have indeed resulted in substantial changes in stream temperature.

Comment C9:

Section 3.3.3.2 of the Analytical Methods section describes a series of assumptions and modeling scenarios that suggest very little data on these systems exists (and no data is presented). The Scott River in particular seems to have been modeled with very little information other than some current flow data (Table 3.2). With regard to the other tributaries, the point is made that changes in effective shade and stream channel dimensions can have an impact on stream temperature, which is no doubt true, but the evidence that changes in either of these areas have taken place in the tributaries seems largely anecdotal. There is some vague mention of changes in land use and the effects that flooding may have had on stream channel width and riparian vegetation, but no data on this is presented (section 2.5.2.2). The subsequent analysis of the impacts of different levels of effective shade demonstrates that there could be an impact, but little evidence is provided to suggest that there actually has been a change in riparian vegetation. Similarly, a discussion in section 4.2.4.1 on the potential impacts of sediment load on temperature in the tributaries cites a higher peak stream temperature the year after a flood (on the basis of seven years of data) as evidence that sediment loads are a factor which seems very shaky. This is then followed up by a statement describing modeling results that suggest a doubling of stream width can increase temperatures 1-2 C, but there is no data presented to suggest that stream widening in any of the tributaries has occurred.

Response C9:

Regional Water Board staff agree that data quantifying the relationship of groundwater use to surface flows in Scott Valley is lacking. The effects of the substantial interaction of groundwater and surface water on Scott River temperatures were analyzed in the Scott River temperature Total Maximum Daily Load analysis (Regional Water Board 2005). That analysis demonstrated the substantial influence of groundwater accretion on Scott River temperatures, as well as the need for a better understanding of the impacts of groundwater use on surface flows. Accordingly, a groundwater study of Scott Valley has been initiated to better understand the interaction of groundwater and surface water in Scott Valley.

Our approach to handling the uncertainty associated with unimpaired flows is to provide analyses that bracket the range of uncertainty. We found that only the flows and temperatures associated with the highest flow scenario had a significant effect on Klamath River temperatures. However, the analysis conducted by Regional Water Board staff indicates the conditions depicted in the highest flow scenario are likely to overestimate natural flows and underestimate natural temperatures. Accordingly, Regional Water Board staff chose not to assign an allocation to Scott River flows. Regional Water Board staff believe this is an appropriate approach to using the data available in a process that requires us to make decisions based on the best available information.

The refernces cited in Section 2.5.2.2 document the levels of water diversion in the basin (also discussed in section 1.6.6), as well as the history of substantial mining and timber harvest throughout the basin. It was not our intent to quantify those effects in section 2.5.2.2, rather to acknowledge that they have occurred.

Regional Water Board staff have bolstered the discussion of the evidence that channel widening and loss of riparian vegetation has occurred in section 2.5.8, which discusses the effects of sediment on temperatures.

Regional Water Board staff have added to the discussion of pre- and post-flood temperature data presented in section 2.5.8. We find the data and analysis persuasive. Similarly, we find the data, analysis, and conclusions presented in the USFS' assessment of the 1997 flood to be persuasive.

Comment C10:

As with question (3) above, I also find myself wondering whether there have been trends toward increasing air temperatures in the Basin (i.e. climate change). This would be another area in which data certainly exists, and would seem important to explore when trying to identify potential sources of increased stream temperature.

I do not want to be overly harsh here, but unless there is substantially more data and analysis of this issue than has been presented in these documents, my opinion is that there is insufficient information to make any informed judgments.

Response C10:

Regional Water Board staff have added a discussion of the increase in air and water temperatures in Section 1.6.4, Climate. The added text discusses Bartholow's (2005) findings that average Klamath Basin air temperatures have increased by 0.5 ^{o}C per decade.

Comment C11:

(4) Assessing the linkage between water quality and fish disease.
I have read through these sections and the conclusions, based on my very meager knowledge in these areas, appear to be reasonable. That said, I have no background in the biology of fish or any other form of macrobiota, so I am not at all qualified to make judgments on the scientific basis for establishing linkages between water quality and fish disease. I would, however, suggest that Professor Hans Paerl at the University of North Carolina's Institute for Marine Sciences, would be someone capable of providing a knowledgeable review in this area or, at a minimum, could point toward other individuals with related expertise.

Response C11:

Thank you for your review and recommendation. The peer review of the Klamath River TMDLS staff report included others with fishery related backgrounds. In addition, resource agencies such as California Fish and Game, United States Fish and Wildlife Service, National Marine Fisheries Service, and Tribal fisheries programs have participated in reviews of the document. Due to the uniformly positive response to these sections no further peer review will be requested.

Comments of: Desiree D. Tullos, PhD
Assistant Professor,
Oregon State University
Biological and Ecological Engineering

Comment T1:

1.0 Nutrient, chlorophyll-a, *Microcystis*, and microcystin targets for Copco I and II, and Iron Gate reservoirs

I understand that these allocations and numeric targets were designed to control blue-green algae blooms and reduce the public health risks associated with algal toxins. I have summarized comments on the protection provided by the proposed TMDL for each constituent in the table below, and include specific issues that should be addressed or clarified in revisions to this Staff Report. It is my belief that, if fully implemented, this TMDL would be protective of beneficial uses, with the exception of the *Microcystis aeruginosa* cell density, which I understand will allow for a 50% exceedance probability.

Type	Water Quality constituent	Recommended regulation	Comments on beneficial use protection
Load allocation	Nutrient loading from reservoir sediments	0 load	This will certainly protect beneficial uses, but it is unclear how this could actually be successfully implemented.
Numeric target	Suspended algae chlorophyll-a	10 μg/L	I have some lingering questions. The "sharp increase in Microcystis aeruginosa cell density above 10mg/L Chl a" (Section 2, pages 19-21) is not as clear of a threshold as document implies. Please see comments below.
Numeric target	Microcystis aeruginosa cell density	20,000 cells/mL	Based on WHO criteria for low risk exposure. Appears to be protective of human health and beneficial uses, however, is 50% probability of exceeding low effects threshold (Section 2, page 23) good enough?
Numeric target	Microcystin	4 μg/L	Based on WHO criteria for low risk exposure. Protective of human health and beneficial uses.

Response T1:

Regional Board staff believe that the reviewers interpretation that the *Microcystis aeruginosa* cell density target represents a 50% probability of the exceedance of the low effects threshold results from an artifact of the manner in which the probability plots were calculated. Since the development of the peer review draft TMDL staff report, a technical memorandum has been released (Toxigenic *Microcystis aeruginosa* bloom dynamics and cell density/chlorophyll *a* relationships with microcystin toxin in the Klamath River, 2005-2008 – Kann and Corum 2009) that more completely discusses the risk of exceeding *Microcystis aeruginosa* cell density and microcystin target levels at a chlorophyll-*a* density of 10 µg/L. This information has been incorporated into Section 2.3.2.2.

The probability plots are a good tool for illustrating the relationship between the independent variables (i.e., chlorophyll-a concentrations and *Microcystis aeruginosa* cell densities) and the dependent variable (microcystin concentration). However the plots require an averaging algorithm that limits an evaluation of the probability of exceedance at a specific threshold. It is possible to calculate the exceedance probability at a specific level for the independent variables. The exceedance probability for the microcystin thresholds for several specific values of the independent variables are presented in Table 2.7 in Section 2.3.2.2. The point specific evaluation demonstrates that when chlorophyll-a was less than 10 µg/L that the exceedance frequencies of the public health thresholds for *Microcystis aeruginosa* density or microcystin concentration were less than 10%.

Comment T2:

Section 2, page 21 and 22 (Figures 2.3 and 2.4). Why were the Chl a – Exceedance probabilities not modeled for the numeric target (10µg/L)? If I am reading Figure 2.3 correctly, it appears that the transition actually occurs under 10µg/L for 20K and 40K cells/ml MSAE. Further, for 100K cells/ml MSAE and 20 µg/L, why were these not modeled for the higher Chl a concentrations, as the lower values were?

Response T2:

The model was run for all values of Chl-a that were measured as part of the monitoring program. In the peer review draft the probability model plot for *Microcystis aeruginosa* was erroneously presented twice and the probability model plots for microcystin were not included. This error has been corrected. The probability plots also use the same category median which introduces uncertainty for any direct interpolation from the graph regarding a precise threshold boundary. The inclusion of Table 2.7 in Section 2.3.2.2, which lists threshold values for each model component resolves this issue.

Comment T3:

Also, the document references that monitoring targets are provided in Chapter 7, though this was not included in the document I received. Further, no implementation plan was provided, and thus, it is hard for me to evaluate these TMDL regulations without some sense of how they might be implemented (and monitored), especially given the

dependence of these water quality conditions on flow modification (see section below) in the river.
Response T3: Chapters 6 and 7 are not included in the scope of the technical peer review and were not complete when the peer review was conducted. These chapters are included in the public review draft. In addition, flow modification is outside the scope of the TMDL and is addressed through other regulatory processes.

Comment T4: **2.0 Load allocations for temperature and dissolved oxygen in Copco and Iron Gate Reservoirs to support salmonid beneficial uses.** I understand that these load allocations are intended to protect the beneficial uses associated with cold freshwater habitat, spawning, migration, and early development, migration for redband/rainbow trout. My understanding is that the TMDL is a load allocation for DO and temperature during the months of May to October for 85% DO at a temperature of 18.7^{o} C. I also understand that the Regional Water Quality Board staff are proposing revisions to DO objectives, however, I do want to note my concern that the current DO background conditions are based on inappropriate data for this purpose. The proposed alternatives (Section 2, page 7) should protect these beneficial uses, if adopted and implemented. I believe the targets for overlapping temperature and DO "lens" is valid and should protect beneficial uses.
Response T4: It appears that the review comment is in reference to the current DO background objectives included in Table 3.1 of the Basin Plan. If so, the Regional Board agrees with the comment that the Table 3.1 "background" values based on daytime grab samples do not represent true daily minimums. This is why the Regional Board is proposing the use of 85% saturation at estimated natural temperatures as an alternative method for estimated background DO (see Appendix 1).

Comment T5: Please clarify how core vs. non-core designations will be established.
Response T5: The USEPA (2003) defines core habitats as those that support a moderate to high density of salmonids, whereas non-core habitats are defined as moderate to low density-supporting habitats. Ultimately, the designation of these categories to a specific water body, or reach of a water body, will require a site-specific evaluation, which is beyond the scope of the TMDL analysis. Regional Water Board staff have generally interpreted the core designation to apply to lower order streams where spawning and rearing occurs, and the non-core designation to apply to higher order streams that function primarily as migration corridors with low density rearing also occurring at refugia. The USEPA guidance document (2003) includes further guidance for making these determinations.

Comment T6:

Estimated natural temperatures plotted in Figure 2.12 (Section 2, page 47) are questionable due to model limitations (see comments on model below). Using such a coarse level of bathymetry (estimated from USGS topos) can introduce substantial error into the models. While I understand that detailed bathymetry may not be available, some analysis of uncertainty in temperature estimates is warranted as part of this analysis since this is such a fundamental part of the TMDL.

Response T6:

Klamath River model bathymetry was derived using the best available data and was deemed sufficient for the purpose of this study. The bathymetric representation enabled the model to reproduce observed hydrodynamic characteristics reasonably well. The temperature calibration, for example, demonstrates the model's ability to represent both observed magnitudes and trends.

Comment T7:

I have some concern regarding the monthly average target for the reservoir tailraces, while the TMDL document acknowledges the influence of reservoirs on daily temperatures and the biological implications of those shifts (Section 2, pages 38 and 39). Might a seven-day moving average be applied to the tailrace temperature target as well? I believe this would be more protective of the beneficial uses this TMDL is trying to address.

Response T7:

Regional Water Board staff chose a monthly average temperature based on the fact that the developed estimates rely on a single season. Interannual variability of the monthly mean is less than metrics based on a 7-day time frame. Numeric targets are simply metrics to track compliance with the TMDL allocations. Ultimately, it is the allocations that provide the protection to beneficial uses. The temperature allocations to the reservoirs are set to equal natural receiving water temperatures, and achieving these allocations, whether data is computed as 7-day moving average or monthly average, would meet the water quality standards.

Comment T8:

Again, implementation is a major concern for these targets. It is my understanding that implementation would require substantial reoperation of the dams and/or new inlet structures to achieve these targets. Given the nonbinding agreement to decommission the dams in 2020, it is unclear to me whether such investment would occur in the interim. Thus, it is relevant to ask whether these targets will protect beneficial uses if not implemented until a decommissioning occurs. Throughout the anticipated delays in decision making about and implementation of the decommissioning or alternatives, it is critical that these targets be implemented in the interim to protect beneficial uses.

Response T8:

Actions taken by PacifiCorp to implement the Klamath TMDL are dependent on the outcome of the on-going settlement agreement development process. The Klamath Basin Restoration Agreement (KBRA) is a negotiated settlement agreement between as many as 26 different parties designed to settle long-standing disputes in the Klamath River basin. It focuses on water allocations in the upper basin, provides for fisheries restoration and is structured around the central assumption that an agreement to remove the lower four Klamath River Dams will be reached. On November 13, 2008, an Agreement in Principle (AIP) to remove four Klamath River dams was announced after negotiations between the federal government, representatives from the state of California, the state of Oregon, and PacifiCorp. Regional Water Board staff were not a party to the KBRA or AIP negotiations. The final agreement regarding the dams may affect the TMDL implementation schedule, which relies on the FERC relicensing process and subsequent water quality certification by the State Water Board. As currently drafted, the AIP contemplates federal legislation that would allow PacifiCorps to remain on annual licenses from FERC, thereby indefinitely delaying the 401 certification and Clean Water Act compliance. The Regional Water Board directed staff to monitor settlement developments and staff has provided input to the parties on appropriate water quality measures to address TMDL compliance during the interim periods before a decision regarding dam removal is made and, if made, between that time and dam removal.

Comment T9:

3.0 Assessment of tributary streamflow rates on stream temperatures.
While projections of streamflows from the tributaries are problematic due to lack of data, particularly for the Scott River, my concerns regarding stream temperatures are more focused on cumulative effects and the ecological relevance of 5^{o}F temperature increase. Related to implementation and its outcomes on cumulative effects, the narrative objective states that temperature cannot be altered unless demonstrated not to adversely affect beneficial uses. How will adverse effects be determined? That is, how will multiple actions be evaluated that could create adverse effects cumulatively? My second concern regarding the ecological relevance of 5^{o}F temperature increase may simply be addressed with some clarification of how the 5^{o}F limit was established. Also, please clarify that this is 5^{o}F basinwide, as opposed to 5^{o}F per action. My concerns related to establishing "natural receiving water temperatures" apply here as well.

Response T9:

Regional Water Board staff rely on the USEPA's temperature guidance to evaluate adverse effects to salmonids related to temperature, as stated in Chapter 2. In regards to the 5 ^{o}F temperature increase, because temperatures are already higher than optimal for salmonids through much of the spring, summer, and fall months, staff have concluded that beneficial uses already are being adversely affected, and thus the water quality standard becomes no temperature increase, and the 5 ^{o}F increase is not invoked. The 5 ^{o}F limit was established in 1972 when the Water Quality Control Plan for the North Coast was first developed, and applies at any time or place.

Comment T10:

4.0 Linkages between water quality and fish disease
I understand that improving the overall status of fish populations is the key end point to restoring beneficial uses of the Klamath River. To this end, I do believe the analysis presented in the TMDL staff report on linkages between water quality impairment and impacts on fish disease is based upon sound scientific knowledge, methods, and practices. The conceptual models and well-supported text provide a solid and commendable overview of current science.

Response T10: Thank you.

Comment T11:

5.0 Additional concerns
As indicated in the discussion above, I have some additional concerns regarding the development and implementation of this TMDL. I also found that the document needs substantial editing, with numerous typos throughout, syntax errors (watch missing commas and affects vs. effects), superfluous and duplicative text, and figure axes without units. In addition, a figure with the location of the Copco and Iron Gate reservoirs would be very helpful. Finally, numbering pages continuously throughout the document, as opposed to section by section, would be helpful for providing comments.

Response T11:

Implementation issues regarding the Klamath River TMDL will be subject to an ongoing adaptive management process but are outside the scope of this technical review. It is the responsibility of the Regional Water Board to identify allocations that will restore supporting conditions for beneficial uses. The Regional Water Board acknowledges that there are several challenging issues related to implementation but it is beyond the purview of the Regional Water Board to dictate specifically how TMDL allocations be achieved.

The Regional Water Board staff will address editing issues prior to the release of the public review draft. Location maps will be added to enhance reader understanding of geographical setting.

Comment T12:

Modeling efforts to establish the "natural" conditions. As noted previously, I have concerns regarding the resolution of bathymetric inputs to the models and the calibration of the model components with limited data from different years (estuary calibrated for 2004, while Segments 1-5 for 2000 and 2002, and Segments 6-9 for year 2000). Because the model integrated results from CEQUAL- W2, RMA I and II, and EFDC were used as inputs to each other, this calibration scheme seems particularly dubious. Additionally, calibration of the model during using data from a low flow when beneficial uses are particularly susceptible to impairment would greatly strengthen the analysis [sic].

Related to this, I disagree with the statement (Section 5, page 9) that an implicit margin of safety is appropriate "because uncertainty was greatly reduced in the analysis by applying a comprehensive, dynamic numerical model…representing conditions in great detail spatially and temporally." The model is not based on great spatial and temporal detail, and an analysis of model uncertainty is absolutely warranted.

Response T12:

As noted above, the bathymetric representation for the Klamath Model was based on the best available data, and the model is capable of reasonably reproducing the observed hydrodynamic characteristics, e.g., trends and magnitudes of temperature. With regard to calibration, the calibration period was selected considering data availability and hydrologic conditions. The model was tested under a range of hydrologic conditions, and more importantly water quality conditions, since it was calibrated for multiple years and for multiple seasons each of those years. The year 2000 was a close to average year in terms of flow while 2002 was a relatively low flow year. However, the year 2000 exhibited poor water quality conditions, and this was deemed a key consideration for TMDL development. 2004 was primarily selected due to data availability. It's important to note that the routing of flow and mass from upstream to downstream models was implemented only for models during the same year. The estuary EFDC model, for example, used observation data as its upstream boundary condition rather than model output.

An implicit MOS was used not only due to the spatial and temporal detail of the model but due to conservative assumptions that were incorporated into the modeling framework, as noted in the TMDL report.

See also Response C1.

Comment T13:

Relationship of this TMDL to the proposed decommissioning of Klamath River dams.

While I realize that this TMDL document is to be kept clearly distinct from the FERC reclicensing procedure for the Klamath Hydropower project (Section 2, page 2), it is relevant and critical to consider the relationship between the proposed TMDL and potential decommissioning. I suggest adding a discussion on how this TMDL might restrict or otherwise effect plans for removal of the 4 dams (Copco I and II, JC Boyle, and Iron Gate) on the Klamath River. Conversely, the Staff Report should establish a strategy for reconsidering the TMDL following the decommissioning. In addition, the Staff Report should consider how the TMDL targets can be met during the interim period between approval of the targets and decommissioning, which may extend well beyond the proposed plans for decommissioning in 2020. In this sense, it is hard to evaluate the TMDL's ability to protect beneficial uses without an analysis of the relationships between the proposed targets and decision making about the Klamath Hydropower project.

Response T13:

See Responses T8 and T11. Also, based on the TMDL modeling analysis, the TMDL allocations and targets would be achieved should the dams be decommissioned. Regional Water Board staff do not believe the TMDL would be reconsidered following a potential decommissioning, though the TMDL implementation MOA between the Regional Water Board, ODEQ, and USEPA Regions 9 and 10 does incorporate joint adaptive management and TMDL reconsideration.

Comment T14:

Implementation and monitoring of this TMDL.
It is difficult to provide an informed review of and meaningful feedback on this staff report without the accompanying monitoring and implementation plans. It is not appropriate for reviewers to project how the targets will be implemented, and yet, it is impossible to truly understand the impacts of the targets without some sense of how they will be applied. For example, are the secondary targets (e.g. “0 miles of excess sediment impact”) even feasible? If these targets are unrealistic, what is the outcome of not meeting them? Similarly, it is clear that flow modifications to the river play a large role in the water quality of the river. Related to implementation, if the dams are reducing peak flow from 20-25% in May, and increasing minimum summer flows (Section 1, page 22), then some flow modifications are needed, which influence a number of water quality impairments addressed within
this TMDL, including:

- Flushing flows to prevent periphyton as substrate for C. Shasta (page 31)
- Summer low flows for dessication of polycheates (page 32)
- Exposure of juveniles to C. Shasta (page 42)
- Flushing sediment (page 70)

The relationships between flow, temperature, DO, salmon, and C. Shasta could be further developed in this TMDL. While I understand that altered flow that affects habitat conditions is not directly addressed in this TMDL (Section 2, page 2), it is impossible to consider whether this TMDL is achievable given the extensive modifications, particularly Lewiston and Trinity flow diversions and Copco and Iron Gate regulation of flow, in the Klamath River system.

Response T14:

Targets are expressions of the conditions that meet water quality objectives and are not independently enforceable. We believe the secondary targets are achievable over time, but recognize that the time-frame for achieving many of the targets is long. Yet, we are required to develop the targets as a quantification of conditions when water quality objectives are achieved.

Comment T15:

In summary, taken as a whole, the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. However, my concerns, described above, limit my confidence in the ability of the TMDL to protect the beneficial uses of

the Klamath River. Please feel free to contact me with any questions or requests for additional information.
Response T15: Thank you for your thorough review.

Comments of: **Dr. G. Mathias Kondolf**
University of California, Berkeley
Department of Landscape Architecture & Environmental Planning

Comment K1:

General Comment
Overall the document reads well, and clearly explains processes by which water quality degradation occurs. I found the explanation of *Ceratomyxa Shasta* to be very clear, and resolved some questions I had harbored about this problem in the past. Below, I limit my comments to areas in which I have background.

Response K1:

Thank you.

Comment K2:

Staff Report, Chapter 1
p.19 Drainage density is influenced largely by infiltration capacity: highly permeable substrates will support lower drainage densities, even in areas of high precipitation. The slopes of Mt Shasta receive very high precipitation, but have low drainage density by virtue of the permeability of the volcanic rocks underlying them. Water yield is still high, but it takes groundwater pathways to springs nearby. By contrast, semiarid badlands have notoriously high drainage densities but low water yield by virtue of the dry climate and low precipitation. Thus, we would not necessarily expect the pattern of drainage density to mirror the pattern of water yield.

Response K2:

The text has been changed to reflect the importance of infiltration capacity in determining drainage density and to remove language linking drainage density to water yield.

Comment K3:

Staff Report, Chapter 1
p.22 Text states that Fig 1.10 shows that pattern of water use has shifted timing of peak spring flows, etc – presumably this is a typo and should refer to Fig 1.11. The basis of Figure 1.11 should be better explained. How much of this figure is based on the Bureau's natural flow study? Were the mean monthly flows in Scott and Shasta Rivers integrated later or as part of the Bureau study? Note that the Bureau study did not get rave reviews from the NRC panel (NRC 2007).

Response K3:

A citation has been added to clarify that the Scott and Shasta river flows were published by the USGS. The USBR's natural flow study represents that best available natural flow estimates at the time of document preparation, and are suitable for the purposes of illustrating general comparisons.

Comment K4:

Staff Report Chapter 2
General: How would the proposed revisions to the DO objectives change the frequency and duration that the river fails to meet the objectives? It is not obvious how many DO data have been collected and what patterns emerge from them. Even under pre-disturbance conditions, we would not expect the Klamath River to have the same water quality of a mountain trout stream, so a different standard is reasonable, but what exactly is the basis for the proposed standards?

Response K4:

In the TMDL problem statement the available quality assured dissolved oxygen data for the Klamath River is evaluated relative to both the existing DO objectives and the proposed DO objective (i.e., 85% saturation at natural temperatures). Table 2.10 and Figure 2.24 provide the percent of measurements that fall below the DO objective for Klamath River reaches below Iron Gate Dam (8.0 mg/L). The analysis included nine stations where data sondes had been deployed May to October for 2004 – 2006. The quality assured data resulted in several thousand validated samples for each station. The same analysis was conducted for percent saturation. The range of violations for percent saturation (Table 2.11 and Figure 2.25) ranged from a minimum of 0% of measurements below 85% DO saturation at several stations in 2006 to 35% of measurements below 85% DO saturation at the station located above Scott River. The TMDL model analysis of dissolved oxygen conditions under natural conditions baseline alerted Regional Water Board staff to the need for a revised site-specific DO objective for the Klamath River. The natural conditions baseline modeling scenario indicated that it was not possible to meet the life-cycle and existing DO objectives in the Klamath River under natural conditions. These model runs confirm your observation that the Klamath River is not a typical cold mountain trout stream.

Appendix 1 of the Klamath TMDL Staff Report details the selection of the proposed site-specific DO objective for the Klamath River in California.

Comment K5:

Staff Report Chapter 2
p.34 *Degraded channel habitat*. Reading this section I noted that channel simplification can lead to less hyporheic exchange, but I see you brought this up later. Another consideration that should not be ignored in a conceptual model of how processes have changed on the Klamath River:
Prior to construction of the railroad in the early 20th century, during floods, the Klamath River between Klamath Falls and Keno overflowed into Lower Klamath Lake (LKL), where by virtue of its long residence time, floodwaters would have deposited suspended sediment and nutrients. Loss of this former connectivity to the lake – in effect loss of a floodplain and wetland storage function - probably produced a significant increase in flood peaks and reduction in removal of nitrogen and other nutrients. Much of the water that overflowed into LKL probably evaporated from the shallow lake surface, but some is

known to have returned back to the river when, on the recession limb of the flood, river stage dropped below the elevation of the water surface of LKL. The characteristics of this return flow were not documented, but it's likely to have been warmer than the original flood waters. The hydrologic implications of this seasonal overflow into LKL (and its loss following construction of the railroad) were not adequately analyzed in the Bureau's Natural Flow Study (NRC 2007).
Response K5: The Regional Water Board agrees that hydrologic changes to Lower Klamath Lake have likely resulted in both temperature and nutrient dynamic changes that need to be accounted for in any future updates of the conceptual model. For the current purpose of the development of initial allocations to the Klamath River mainstem from the Lost River basin the existing TMDL model adequately accounts for loading from the Lost River basin via the Klamath Straits Drain and Lost River Diversion Canal. In regards to the temperature of returning LKL flood waters, the temperature was most certainly different from the temperature of the original flood waters, but was likely to be close to that of UKL, based on their proximity and similarity. Thus, the temperature of the returning waters was not likely to have greatly altered the temperature of the Klamath River.

Comment K6: **Staff Report Chapter 2** p.34-35 Clarify the *effects of increased fine sediment delivery to the channel* and resultant bed fining and pool filling, versus sediment starvation and bed coarsening. On p.34, the former is cited as increasing periphyton growth, while on p.35 the latter is cited as producing the same effect (because the substrate is less mobile). Perhaps they both can produce the same result of more periphyton growth, but the mechanisms need to be explained more clearly to resolve the apparent discrepancy.
Response K6: The text has been revised to more clearly delineate the effects related to: 1) reduced desiccation due to less variation in flow regime; 2) more stable growth substrate due to channel coarsening; and 3) the reduced rate of scour / dislodgment of periphyton due to reduced rate of impingement from reduced gravel transport downstream. The discussion of the deposition of fine organic matter (senesced phytoplankton exported from upstream reservoirs) has been moved to the discussion related to impoundment effects on fish disease related processes.

Comment K7: **Staff Report Chapter 2** p.34 *Altered flow conditions*. Note that Copco and Iron Gate together impound only about 5% of the mean annual runoff. This is a very small *impounded runoff ratio* by California standards (Kondolf and Batalla 2005). (Compare to 80% for the Sacramento and 120% for the San Joaquin overall, higher for some specific drainages: 460% for Putah Creek, 240% for Stanislaus.) Storage by Upper Klamath Lake may be more

significant, probably affecting low flows the most. It's not clear that the frequency or magnitude of scouring flows is less now than in the late 19th century, because Copco and Iron Gate would have little storage effect, and counteracting reservoir storage effects was the significant loss of flood overflow into LKL. Moreover, to have increased deposition of sediment in the river bed you need not only to reduce scouring flows, but you need a sediment source below the dam, because the dams are trapping at least the coarser fraction of the sediment load.

Response K7:

Regional Water Board staff have revised the text to clarify that scouring flows are also dependent on sediment dynamics, and have removed the text discussing increased rates of deposition.

Comment K8:

Staff Report Chapter 2

p.35 *Dams halt downstream transport of gravel…* The hypothesized effect is probably correct in that directly below Iron Gate substrate has significantly coarsened, as shown by surficial grain size measurements (CH2MHill 2003). It is possible to scour periphyton from stable cobble beds by transporting sand over them, but sand is trapped by Iron Gate Reservoir so the reach immediately below the dam would be starved of sand. Note that this effect would persist downstream only until tributary contributions of sediment became significant. Below Iron Gate, Bogus Creek delivers enough gravel to the mainstem (some of which is exotic gravel placed in the channel to improve spawning habitat in the tributary) to produce mobile gravel bars starting just below the US Geological Survey gauge, about 100m downstream of the tributary confluence.

Response K8:

Regional Water Board staff agree that this process only occurs in a limited reach below Iron gate dam, but nonetheless it occurs and we believe it should be accounted for in our conceptual model, particularly because it relates to the acute incidence of disease in that reach.

Comment K9:

Staff Report Chapter 2

p.36-37 *Thermal processes related to sediment load.* It seems the document is arguing that several separate processes occur. It might be useful to clearly distinguish them, as the reader is likely to conflate them now.

The first paragraph refers to "…pool filling, increased width, decreased depth, and/or reduction of intergravel flow."

The second paragraph notes that sediment can fill pools and narrow channels, so that the river flows over an aggraded surface in what will be a wider channel. Simply by virtue of the increased width (and thus reduced average depth) we can expect more exposure to solar radiation and greater heating.

The second paragraph notes that aggradation can result in loss of riparian vegetation, but the mechanism is not stated. Is it because the aggraded channel exerts more erosive force on banks and undercuts them, causing riparian trees to fall into the channel? (In this case we should probably give some credit to the increased complexity that might result from the large wood in the channel.) Is it because the aggraded channel raises the water table in the adjacent banks and waterlogs riparian trees adapted to better-drained conditions in summer months? Whatever the mechanim(s), explain this better, and if this point is drawn from Lisle's work, cite accordingly.

The third paragraph expands on why a wider, shallower channel will gain more heat in the daytime (and lose more at night). The Poole and Berman (2001) citation is incomplete in the References Cited as only the authors and title are included in the citation, not the journal or report series. Presumably this report documents some of Poole's work in eastern Oregon, where bed complexity is a primary driver of hyporheic flow and moderation of diurnal temperature fluctuations (Poole et al. 2006). This is another mechanism, and should be clearly distinguished from the channel becoming wider and shallower, as it pertains to the form of the longitudinal profile, rather than the cross section.

Channel simplification that reduces the undulations in the bed, can reduce the exchange of surface and groundwater. Two recent studies have documented that more complex channels with significant bed undulations (e.g., pool-riffle alternations) have more hyporheic exchange and moderated diurnal temperature fluctuations. Alicia Arragoni's masters thesis research on the Umatilla (with Poole) documents the moderating effects on diurnal temperature fluctuations of complex bed topography. I believe her research has appeared in Water Resources Research by now, though I have only a draft version on my computer (Aragoni et al, submitted), which I attach. Mark Tompkins' PhD research (2007) documented hyporheic exchange in complex reaches reduced diurnal fluctuations by 2^{o}C or more on Deer Creek in Tehama County.

Response K9:

Regional Water Board staff have re-written this section for clarity and have addressed the issues identified by the reviewer. The Poole citation has been completed and refers to a journal article that presents an overview of human influences on stream heating process.

Comment K10:

Staff Report Chapter 2

The second paragraph on p.37 alludes to reduced permeability, which would result from deposition and infiltration into the bed of finer sediments (silts, clays), but this point is not developed. There are examples in the literature of side channels whose groundwater exchange has been blocked by a surficial layer of silt, such as along the Rhone River in France, where an overlying silt layer was removed explicitly to restore hyporheic exchange (Henry et al. 2002). This has probably occurred in some places in California and Oregon, but I cannot think of an example now. If there is any evidence for such effects on the Klamath or its side channels, this would be useful to present in the TMDL. Also in Australia, 'sand slugs' have reduced hyporehic exchange in many streams (Boulton et al. 2002).

Response K10:

Regional Water Board staff believe that conduction is the appropriate heat exchange mechanism, based on our understanding of the science and review of the literature. We have added language clarifying the way that conductive heat exchange processes act on hyporheic water to influence temperatures.

Comment K11:

Staff Report Chapter 2
p. 37 *Thermal processes related to flow* It may be worth noting that this simple model of more water flowing faster down the channel lies at the heart of most temperature models, but does not account for channel complexity and resulting thermal refugia. In some cases, thermal refuges like 'cool pools' function better at lower flows because they remain more hydrologically isolated from the warming main

Response K11:

Regional water Board staff have added language that clarifies that advective heat exchange works in concert with other heat exchange processes to determine the overall temperature of a stream.

Comment K12:

Staff Report Chapter 2
p.45 *Temperature* It is known that salmonids near the southern end of their range in warmer waters of California have adapted to higher temperatures

Response K12:

Regional Water board staff have added text acknowledging the existence of data that indicates that some populations of southern California steelhead may have higher temperature tolerances. However, we believe that the temperature tolerances suggested by USEPA are appropriate for assessment of temperature conditions in the Klamath, based on studies from the north coast of California (Welsh et al, 2001; Hines and Ambrose, undated).

Comment K13:

Staff Report Chapter 2
p.70, *second paragraph, streambed armoring*. Armoring of the streambed on the Klamath River is the result of trapping of sediment by the upstream dams, not alteration of the flow regime by dams. As noted earlier, Copco and Iron Gate together impound only around 5% of the mean annual runoff and have not reduced peak flows very much, but they do effectively trap all bedload sediment. Moreover, other things being equal, one would expect the greatest armoring below dams that do *not* reduce high flows (like Copco and Iron Gate) because these reaches still have the energy to transport sediment but have lost their coarse sediment load to upstream reservoirs (Kondolf 1997). Dam

Response K13:

Regional Water Board staff have refined the language in the text to remove the emphasis on the role of altered flow regime in the discussion of streambed armoring. Despite the limited range of the river bed that is impacted, the excess accumulation of periphyton in the affected reach appears to play an important role in high levels of parasite infestation.

Comment K14:

Staff Report Chapter 2
p.70, *third paragraph, tributary deltas*. Formation of deltas at tributary confluences is probably attributable to pulses of sediment from the tributaries, rather than reduced competence and transport capacity of the mainstem due to dam

Response K14:

Regional Water Board staff have removed the text attributing effects of the altered flow regime to the sediment deltas at tributaries.

Comment K15:

Staff Report Chapter 2
p. 70, *debate between second and third paragraphs*. Note that these two paragraphs imply contradictory conceptual models, though they are not spelled out. Paragraph 2 implies that transport competence and capacity have been increased by the dams (more scour of gravels) while Paragraph 3 implies that they have been reduced (less ability to mobilize sediments delivered from tributaries).

Response K15:

The changes described in the two previous responses address this comment and resolve the contradiction.

Comment K16:

Staff Report, Chapter 3
p. 13-14, *Scott River flow and temperature*. I found the discussion of interactions among surface flow, groundwater, and water extractions in the Scott Valley to be informative, not knowing much about this topic in advance. I may have missed something in my reading, but it is not clear to me what data constrain the model assumptions here. What temperature data exist, for what locations, etc? Perhaps the document would be more credible if specifics regarding available data and interpolations/estimates needed were spelled out in lieu of terms such as "moderate amount" such as in the passage, "These estimates are based on a moderate amount of verifiable information, couple with reasonable assumptions about the hydrology of the Scott Valley." The next sentence refers to "uncertainty"; to what extent can it be quantified?

Response K16:

Regional Water Board staff have revised the description of the Scott River flows and

temperature analysis, including a discussion of the considerable amount of data used in the development of the Scott River temperature model.

Comment K17: **Staff Report, Chapter 3** p.15 *Trinity River temperature*. I'm surprised there are not better temperature data for the Trinity, given the degree to which it's been studied. Again, perhaps a clearer statement of what is constrained by data, what kinds of interpolations/estimates were required, and what uncertainties would result, could improve the document.
Response K17: Regional Water Board staff have added more text in the discussion of Trinity River to describe our reasoning related to the assignment of the Trinity River temperature boundary condition.

Comment K18: **Staff Report, Chapter 4** Figures 4.1-4.3 seem very effective ways to communicate the conceptual model of nutrients inputs. Can the figures (or supporting text) be modified to indicate which numbers are based on actual field measurement programs and which values are interpolated/estimated? Some indication of the uncertainty in these values?
Response K18: The vector diagrams illustrating pollutant sources for total nitrogen, total phosphorous, organic matter are all based on TMDL computer model simulations. No quantitative uncertainty analysis has been conducted on the TMDL model simulations. However the TMDL model was calibrated and validated during model development. The Regional Water Board is confident that the model estimates provide an adequate basis for assigning initial allocations that will drive TMDL compliance measures. The Klamath River TMDL is an adaptive management process that will be supported by a basin-wide monitoring program. The source assessment and allocations will be reevaluated as part of the adaptive management process.

Comment K19: **Staff Report, Chapter 4** p. 33 *thermal refuges at cold-water tributary mouths*. The effect of increased tributary sediment loads filling in cold water refugia appears to be an important effect. Any citation to support the last sentence of paragraph 2?
Response K19: Two citations supporting this point have been added to the document.

Comment K20: **Appendix 4 Fisheries** This section appears to be a good summary of available data on status of fish in the basin overall. Figures 2-4 are interesting but somewhat difficult to read. Perhaps they would be more readable if the lines showing reaches where fish persist were to be different shades or thicknesses of blue or green, while reaches where fish were extirpated were shades of red or orange.
Response K20: Comment noted. The changes suggested by the reviewer may result in maps that are easier to read. However, we believe the maps present accurate information, and due to technical reasons we are not altering the map depiction.

Comment K21: **Appendix 5-D Determination of Tributary Flow** The approach presented is reasonable as a first cut, but the explanation seems to leave many questions hanging. First, the net increase in flow from one gauge to the next is attributed to the intervening tributaries, and the water yield is assumed to be a constant per unit area, i.e. tributary responsible for 40% of the increased drainage area is assumed to produce 40% of the increased flow. Lacking any information beyond drainage area, this is reasonable, but precipitation is highly variable spatially, so it would seem that an isohyetal map should be consulted to assess the degree to which this simplification might result in significant over- or under-estimates in allocation of flow to individual tributaries. Second, the USGS method involves monthly averages, whereas the TMDL model used 7-day average values. How exactly was this done? For each water year, were days 1-7, 8-14, 15-21, etc averaged? (i.e., Oct 1-7, Oct 8-15, etc) How different were the results for high-flow months vs baseflow months? (I would expect some significant differences.) And finally, who is the mysterious "Mr. M, Flug"?
Response K21: Comment noted. We agree that the excerpted text doesn't provide the detail that would answer the questions posed by the reviewer. However, the text is excerpted from a Pacificorp report and we can't comment on those details of the analysis, as we were not privy to them. Finally, we believe that the mysterious M. Flug is Marshall Flug of the USGS.

APPENDIX 7. REFERENCES

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